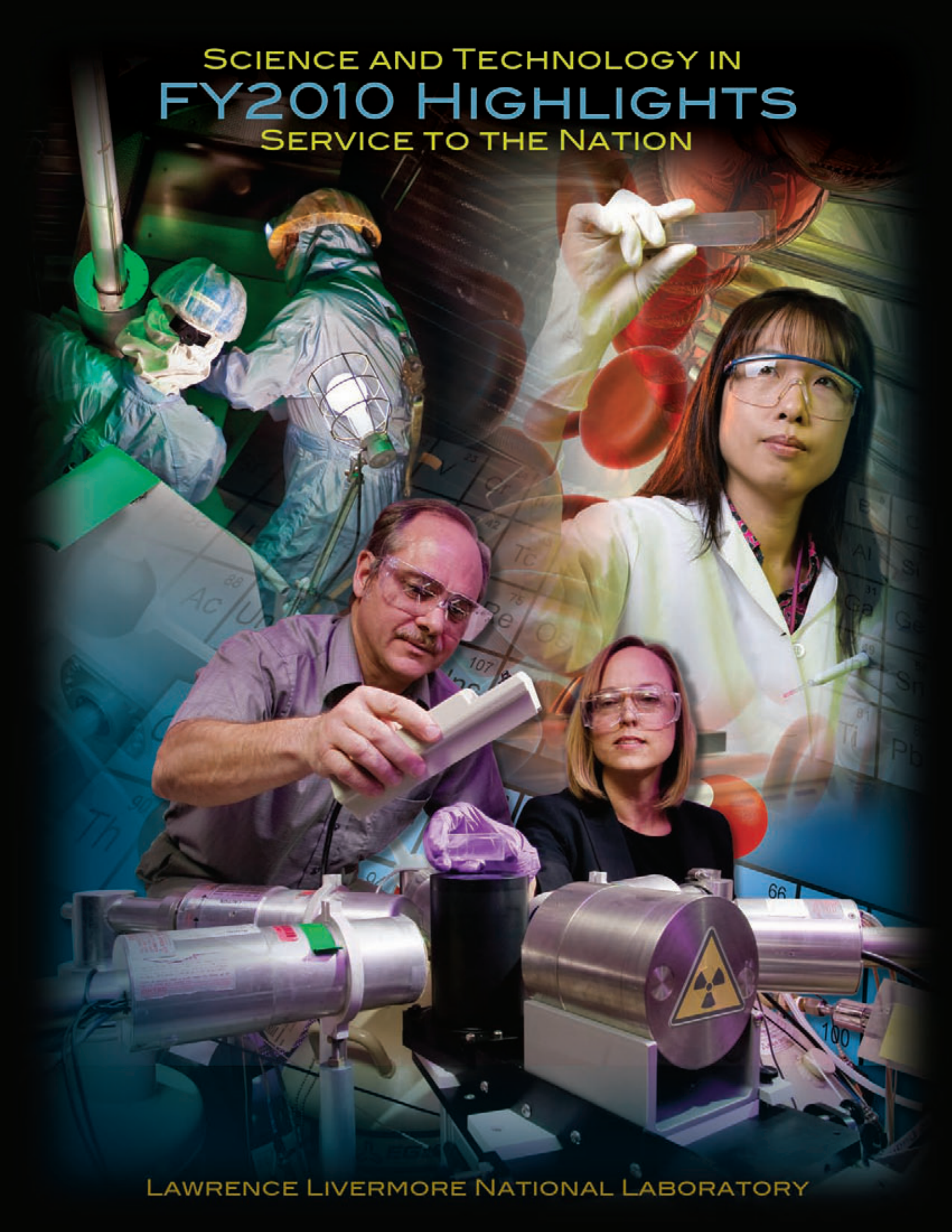
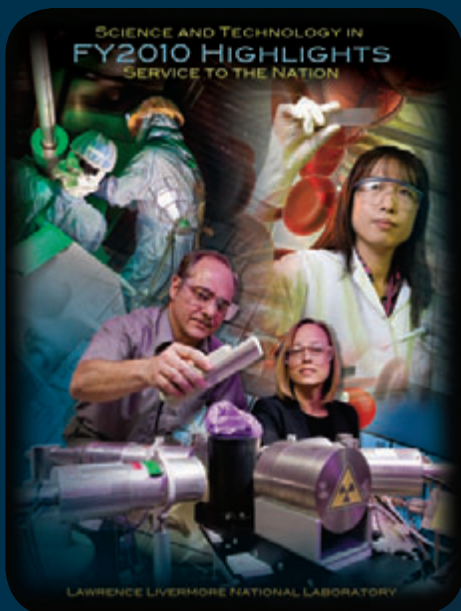


SCIENCE AND TECHNOLOGY IN FY2010 HIGHLIGHTS

SERVICE TO THE NATION



LAWRENCE LIVERMORE NATIONAL LABORATORY



ABOUT THE COVER

Lawrence Livermore National Laboratory's most valuable asset is its outstanding workforce. The Laboratory stays vibrant by attracting and retaining top-notch people driven by a "passion for mission" and dedicated to scientific and technical excellence in service to the nation. Highly motivated individuals and exceptional multidisciplinary team efforts are responsible for achieving our many programmatic accomplishments in FY2010, making important advances in science and technology, and continually improving operations at the Laboratory.

ABOUT THE LABORATORY

Lawrence Livermore National Laboratory was founded in 1952 to enhance the security of the United States by advancing nuclear weapons science and technology. With our world-class research capabilities, a talented and dedicated workforce, and a tradition of innovation and intellectual integrity, the Laboratory anticipates, develops, and delivers solutions to problems of national and global importance. The Laboratory is managed by Lawrence Livermore National Security, LLC, for the National Nuclear Security Administration within the U.S. Department of Energy.





THE YEAR IN REVIEW

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DIRECTOR'S MESSAGE

Providing innovative science and technology to meet broad national security challenges

This is a very exciting time for Lawrence Livermore National Laboratory (LLNL). There is growing recognition of the need to bring our Laboratory's unique capabilities to bear on many of the most difficult challenges to national security and global stability. The 2010 Nuclear Posture Review reaffirmed our important responsibilities to sustain a safe, secure, and effective nuclear deterrent and prevent nuclear proliferation and terrorism. Setting the nation's course for a more secure nuclear future, the review also recognized the need to modernize the nuclear weapons infrastructure and sustain the science, technology, and engineering base at the Department of Energy's (DOE's) National Nuclear Security Administration (NNSA) laboratories, including LLNL.

As described in this annual report for fiscal year (FY) 2010, we are making remarkable advances in science, engineering, and technology in support of our missions. One particularly notable

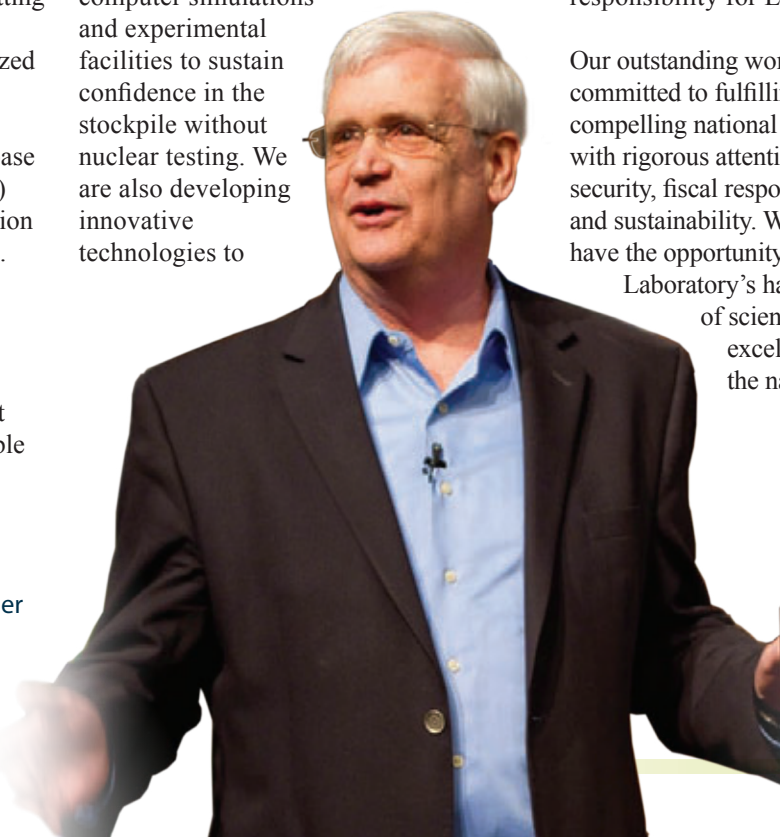
achievement is the fielding of the first integrated fusion ignition experiment at the National Ignition Facility (NIF). NIF is being used to study the fundamental physics of nuclear weapons and the cosmos and to demonstrate fusion as a potential source of clean energy.

Among our other achievements, we are using some of the world's most advanced computer simulations and experimental facilities to sustain confidence in the stockpile without nuclear testing. We are also developing innovative technologies to

prevent nuclear smuggling, enhance biosecurity and human health, reduce the impact of fossil fuel use, and find energy alternatives. Our analytical and technical expertise is being applied to counter the threats affecting global stability in the 21st century, such as the dangers posed by our dependence on an increasingly networked world. These are all growing areas of responsibility for LLNL.

Our outstanding workforce is committed to fulfilling the Laboratory's compelling national security mission with rigorous attention to safety, security, fiscal responsibility, efficiency, and sustainability. We are honored to have the opportunity to continue the Laboratory's half-century tradition of scientific and technical excellence in service to the nation.

George H. Miller
LLNL Director
LLNS President



FY2010 HIGHLIGHTS

Fusion Experiments Begin at NIF

In September, the National Ignition Campaign successfully conducted the first integrated fusion ignition experiment. This important milestone followed the installation of safety systems and commissioning of many new diagnostics and the Cryogenic Target System. In addition, stockpile stewardship experimental campaigns were launched, and high-energy-density science experiments were conducted as part of NIF's broader mission as a user facility.

Scientific Rigor for Stockpile Stewardship

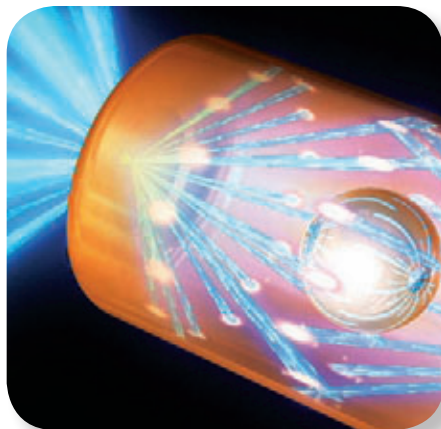
LLNL added scientific rigor to the annual assessment process by developing and applying better physics models and upgraded data sets. We conducted several major hydrodynamics tests with exemplary high-fidelity simulation modeling of experimental results and made important progress in improving codes for efficient use on our next supercomputer, Sequoia. The Laboratory also brought into operation new technologies for use at the Pantex Plant and provided technical expertise for the Nuclear Posture Review.

Improved Capabilities to Enhance Global Security

We developed improved methods for detecting nuclear smuggling and worked with government agencies and private industry to field more capable detection systems. We also made advances in cyber security and enhanced space situational awareness and provided a wide range of analytical and technical support to U.S. arms control negotiators, agencies responsible for domestic security, and the intelligence community.

Contributions to Energy and Environmental Security

LLNL's scientific, engineering, and computational resources were broadly applied to understand in detail the implications and reduce the environmental impact of fossil fuel use. Our researchers engaged in carbon capture



Experiments are under way at the National Ignition Facility (left) to achieve fusion energy—the power of the Sun. Laser light heats the walls inside a small cylinder called a hohlraum (above), creating x rays that implode and ignite a small target filled with fusion fuel.

and sequestration efforts around the world, providing both experimental and computational support. More than two dozen Laboratory engineers and scientists provided technical assistance for dealing with the Deepwater Horizon oil spill as part of the DOE emergency response team.

Advances in Science and Technology

Laboratory researchers participated in collaborations that created a new

superheavy element, discovered a new hominid species, and showed how peptides in living organisms regulate the growth of bones and teeth. We developed two miniature biodetection devices and fabricated the sophisticated multilayer optics used in the recently launched Solar Dynamics Observatory. Six technologies developed by LLNL researchers and partners won 2010 R&D 100 Awards. We granted 24 new licenses to commercialize promising Laboratory-developed technologies; other technologies are being prepared for the marketplace through our Entrepreneurs in Readiness program.

Strengthened Management and Operations

Our commitment to safe, secure, and sustainable operations was recognized with NNSA's approval of our Integrated Safety Management System and ISO 14001 certification of our Environmental Management System. We received a number of "Going Green" awards for sustainable practices and buildings, and NIF won the Project of the Year Award from the Project Management Institute. Our Contractor Assurance System passed rigorous internal and external assessments, paving the way for streamlined oversight of the Laboratory.



As part of our broad national security mission and drawing on our expertise in computations, LLNL is dramatically increasing capabilities to detect, characterize, and combat malicious cyber attacks on large computer networks.

A Joint Test Assembly for the W87 warhead, carried on an Air Force Minuteman III intercontinental ballistic missile, successfully splashes down at the end of a flight test. Data collected from onboard sensors are used to evaluate warhead reliability.



NUCLEAR DETERRENCE

Ensuring the safety, security, and effectiveness of the enduring stockpile



LLNL researchers are developing tiny, rugged sensors that could be embedded inside every nuclear weapon to report on the health of critical components and on environmental conditions. A 60-micrometer-thick contact stress sensor (shown on a dime for scale) can repeatedly measure changing loads perpendicular to a surface within a weapon system.

Our foremost responsibility as a national security laboratory is to ensure—in the words of the 2010 Nuclear Posture Review—that the nation “will sustain a safe, secure, and effective nuclear arsenal as long as nuclear weapons exist.” Through experiments, theory, and simulations, we investigate the fundamental science of nuclear weapons to understand the effects of aging on weapon materials and weapon performance. The knowledge gained enhances our ability to assess the condition of stockpile weapons, develop modifications as needed, and certify the stockpile without nuclear tests. We also pursue innovations to make the nuclear weapons complex more efficient and effective.

Annual Stockpile Assessment

LLNL completed Cycle 15 of the Annual Stockpile Assessment. To continue to improve these assessments and reduce underlying uncertainties, we completed a major set of upgrades to baseline equation-of-state models for weapons codes. In a joint effort with Los Alamos National Laboratory, we resolved a long-standing systematic difference between the laboratories in fundamental nuclear data

important for modeling nuclear tests. Data exchanges are under way with Los Alamos to implement the Independent Nuclear Weapon Assessment Process, which will strengthen peer review. Teams from both laboratories will each have access to all weapon systems data needed to perform analyses in support of annual assessments, close significant findings, and certify weapon modifications made in life-extension programs.

Stockpile Surveillance

Each year, we perform a wide range of surveillance activities to monitor the condition of LLNL-designed weapons in the stockpile. In FY2010, the Air Force conducted a successful flight test of a Minuteman III intercontinental ballistic missile carrying a Joint Test Assembly (JTA) for the W87 warhead as well as a B-2 bomber flight test with a JTA for the B83 bomb. JTAs are sophisticated weapon-system replicas that use as much actual hardware as feasible and provide telemetry data about performance and flight test conditions. We also developed methods and technologies to improve capabilities for monitoring the health of materials and weapon components in the stockpile.

For example, state-of-the-art radiography methods were used to reconstruct, for the first time, the heterogeneous character of an insensitive high explosive to better understand its performance in weapons as the material ages.

Award-Winning Advances in Weapons Physics

Research efforts are advancing our understanding of the physics of nuclear weapon performance at the level of detail needed to sustain long-term confidence in the stockpile. Physicist Omar Hurricane received an E. O. Lawrence Award for breakthrough work in one important area. A multidisciplinary team he led resolved a previously unexplained 40-year-old anomaly that was one of the factors driving the need for nuclear testing. Now, in simulation codes, a physics-based model can replace an ad hoc calibration factor that had to be adjusted depending on weapon design specifics and nuclear test data. This effort involved combining high-fidelity nonnuclear experiments, the latest simulation tools, and reexamination of archival nuclear test data. Experiments at NIF in 2011 will serve to confirm the model.

The Dawn of Sequoia

Preparations are under way for Sequoia, which is planned to begin operations in 2012 as the world's

fastest supercomputer, with a peak speed of 20 petaflop/s (quadrillion floating-point operations per second). Sequoia represents the next-generation BlueGene technology. Developed by IBM and pioneered at LLNL, BlueGene supercomputers earned IBM the National Medal of Technology and Innovation at a White House ceremony in October 2009. Dawn, a 500-teraflop/s (trillion floating-point operations per second) initial delivery system for Sequoia, is running cutting-edge weapons physics simulations and serving as a test bed for effectively using Sequoia, which will have about 1.6 million processor cores working in parallel. Preparations for Sequoia also included completing a 7.5-megawatt power upgrade to the Terascale Simulation Facility.

Stockpile Stewardship Experiments

Among the many successful hydrodynamic tests this year, we conducted an important stockpile integrated weapon experiment at our Contained Firing Facility (CFF). The test incorporated several new diagnostics, including a technique called optical photonic Doppler velocimetry to obtain greater amounts of higher fidelity data about implosion dynamics. LLNL also supported a test at CFF conducted by Los Alamos. We helped prepare three dual-axis experiments at Los Alamos's

Dual Axis Radiographic Hydrodynamics Test facility and successfully modeled the shot results. Eleven experiments at NIF launched campaigns in support of stockpile stewardship. At the Nevada Test Site, we fired two explosive pulsed-power Phoenix tests. Phoenix aims to provide a greatly enhanced experimental capability for measuring material properties at extremely high pressures and densities.

Support for Pantex Operations

LLNL scientists and engineers are developing new systems and capabilities and providing technical expertise in support of operations at the Pantex Plant, the nation's facility for assembling and disassembling nuclear weapons. We formally released CASTLE, a software package for streamlining the processes that ensure safe operations, for use at Pantex. CASTLE is being applied to several warhead dismantlement programs and the life-extension program for the Los Alamos-designed W76 warhead. We supported Pantex operations to disassemble LLNL-designed W62 warheads, completed a full year ahead of schedule. Laboratory scientists are also pursuing a wide range of projects focused on fundamental aspects of weapons safety, including assessments of lightning threats to Pantex facilities and development of technologies to assess electrostatic discharge issues.



Technicians and scientists monitor test preparations in the control room of the Contained Firing Facility, located at LLNL's remote Site 300. In FY2010, scientists from both Livermore and Los Alamos conducted important hydrodynamics experiments at the facility.

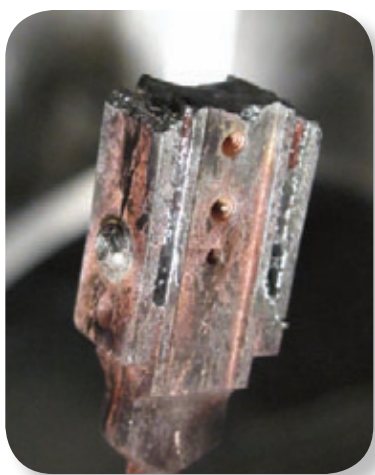
The target for the first integrated fusion ignition experiment is shown mounted in the positioning device at the end of the Cryogenic Target System. The two long arms form a shroud around the cryogenically cooled target to protect it until they open five seconds before the shot.



NATIONAL IGNITION FACILITY

Pursuing fusion ignition experiments and turning NIF into a user facility for stockpile stewardship and high-energy-density science

Preparations were completed and the experimental campaign begun to achieve fusion ignition and burn at NIF, the world's most energetic laser system. NIF experiments will help resolve key issues about nuclear weapon performance, provide valuable insights into the nature of the universe, and advance the prospect of laser fusion as a carbon-free energy source. NIF epitomizes the kind of groundbreaking, versatile “big



The remains of the target assembly are shown after the shot.

science” that has been a hallmark of the Laboratory for more than 50 years.

First Integrated Ignition Experiment

In September 2010, the National Ignition Campaign (NIC) met a major milestone by successfully completing the first integrated fusion ignition experiment. In this test, the 192-beam NIF laser system fired 1 megajoule of laser energy and imploded a peppercorn-size target located at the center of the 10-meter-diameter target chamber. The cryogenically cooled target, inside a small gold hohlraum, was filled with a “dudged” mixture of hydrogen, deuterium, and tritium to optimize the amount of data gathered. All systems operated successfully, including the 26 target diagnostics fielded for the experiment. NIC, which will culminate in tests expected to achieve fusion ignition, is a partnership among LLNL, the Laboratory for Laser Energetics at the University of Rochester, Los Alamos and Sandia national laboratories, and General Atomics, and it benefits from the participation of many other contributors.

New Understanding of Hohlraum Energetics

Prior to launching the ignition campaign, LLNL scientists made important progress

in understanding hohlraum energetics. Earlier NIF experiments measured the amount of laser light absorbed by the hohlraum's inner walls and the resulting flux of the x rays used to implode the target capsule. The principal concern was whether too much of the laser light energy would scatter or heat electrons instead of being converted into x rays. The experiments showed that the hohlraum performs as needed for ignition. Results, however, were puzzling until a breakthrough in theoretical understanding by Laboratory scientists led to a consistently correct explanation of details about the level of scattered laser light and its spectra, the driving energy for the implosion, and the implosion symmetry.

Preparations for Ignition Experiments

The Ignition Preparation Project set the stage for the first integrated fusion ignition experiment and future shots that will use potentially hazardous materials and create radioactive products. As part of this multifaceted effort, we developed safety plans and procedures, trained personnel, and installed systems to provide neutron and radiation protection. Forty-four shield doors, some weighing up to 5 tons, were installed to provide protection in and around the target bay and

beam switchyards. Newly commissioned systems capture tritium from the target chamber exhaust streams and manage contaminated items coming from the target chamber. NNSA authorized the start of low-yield operations involving the use of tritium, beryllium, and depleted uranium in September, following a Management Prestart Review. Many new target diagnostics were installed in FY2010. Hohlraum/capsule diagnostics were added that measure the time history of x-ray emission and precisely determine shock velocities in the target capsule. The new ignition diagnostics include instruments to analyze in detail the neutron yield and measure the gamma-ray spectrum. In addition, we fired several hundred shots during the year to tune and calibrate the laser system, improve pointing accuracy, and validate the focus of beams at the target chamber center. The Cryogenic Target System was also installed and operationally qualified in August.

Target Fabrication, Assembly, and Shot Preparation

Ignition targets are complex, precision assemblies designed, developed, and fabricated by NIC scientists and engineers, with final assembly taking place at LLNL. Essential target components include a hohlraum with an entrance hole at each end to let in the laser light, a target capsule machined to 1-micrometer accuracy with

a fill tube to insert the fuel, the fusion fuel, and a thermal-mechanical package to maintain the target's position and temperature. Under development since 2005, the newly installed 15-meter-long Cryogenic Target System fills the target capsule with liquid fusion fuel, cools the target to form an ice layer of fuel on the inner wall of the capsule, and radiographically characterizes that layer. The capsule temperature must be controlled to ± 0.01 kelvin to maintain the quality of the ice layer while the target is aligned to 1-micrometer accuracy.

High-Energy-Density Science Campaigns

Experimental platforms were commissioned for NIF to probe science issues relevant to both national security work and the physics of the cosmos. The interaction of intense radiation with matter (radiation transport) is particularly important for the Stockpile Stewardship Program. We fielded the necessary diagnostics, demonstrated the ability to fabricate and characterize the complex targets, and conducted the first experiments to gather data to compare to predictions. An initial series of experiments was also completed to study the effect of x rays on valuable national assets such as satellites. NIF beams were focused on a target designed to produce a large flux of x rays, which were used to excite thermal and



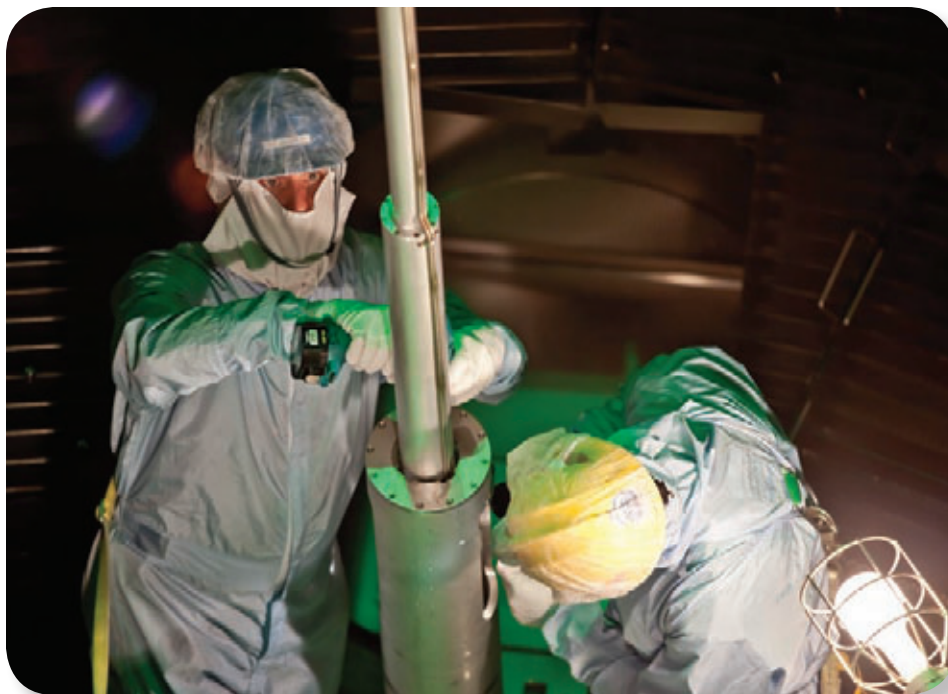
LLNL's precision robotic assembly machine can manipulate tiny fusion target components with unprecedented accuracy in an operating space the size of a sugar cube.

mechanical responses in test objects provided by partner agencies in the Department of Defense. In addition, new capabilities to perform supernova hydrodynamics experiments were successfully tested in NIF shots executed for a research team from the University of Michigan.

NIF User Community

More than 40 proposals were submitted to conduct fundamental high-energy-density science at NIF in the FY2011–12 timeframe. A 12-person review committee, chaired by University of Chicago professor and former Argonne National Laboratory Director Robert Rosner, met in July to evaluate the proposals, which were presented by teams of national and international scientists via Web conferencing. The quality of the submissions was uniformly excellent, and the experiments should lead to groundbreaking science on NIF in the years ahead.

Technicians install a static x-ray imager in the 10-meter-diameter target chamber. One of more than 30 diagnostic instruments installed at NIF, this device helps scientists determine the positioning of laser beamlines within the hohlraum.





Laboratory personnel led a major multiagency full-scale exercise in the San Diego harbor that tested integrated capabilities for detecting nuclear materials onboard small vessels.

GLOBAL SECURITY

Providing expertise and systems solutions to counter WMD proliferation, defend the homeland against terrorism, and enhance global stability

Global security is an enduring LLNL mission. Our researchers strive to make the world safer and more secure by applying the full spectrum of Laboratory capabilities to pressing global issues. They serve as technical experts supporting international nonproliferation and arms control negotiations. They develop advanced technologies and systems to prevent the acquisition or use of weapons of mass destruction (WMD) by nation-states or terrorists. Laboratory initiatives in space situational awareness and cyber security are strengthening U.S. defenses in a networked world. Recognizing that abundant energy and a sustainable environment are key to national security and global stability, our scientists and engineers also work to develop clean

energy technologies and to understand climate change.

Treaty Support

Livermore experts provided technical support to negotiations for the New Strategic Arms Reduction Treaty (New START) and Comprehensive Nuclear-Test-Ban Treaty (CTBT). One scientist spent many months at DOE headquarters helping to develop New START negotiating positions for the U.S. government. Another served as part of the U.S. delegation in Geneva, participating in the Treaty Text Working Group, which was responsible for ensuring that the treaty articles as written accurately conveyed the terms agreed to by the Russian and American delegations, and in other groups that

developed treaty terms, definitions, and protocols. For the CTBT, a Laboratory scientist continued his long-term participation in the Preparatory Commission working group that is developing the treaty-required on-site inspection protocols. Another LLNL scientist contributed to the seismic monitoring portion of the latest National Academy of Sciences study regarding technical considerations associated with U.S. security under the CTBT.

Maritime Detection of Nuclear Materials

LLNL planned and led a successful full-scale exercise at three maritime locations in the San Diego area, conducted concurrently with the U.S. Coast Guard Bay Shield and State of California Golden Guardian 2010 exercises. Held as part of the West Coast Maritime Pilot Program, funded by the Department of Homeland Security (DHS) Domestic Nuclear Detection Office, activities involved 130 personnel from more than a dozen federal, state, and local law-enforcement and first-responder agencies. The exercise provided a real-world test of integrated agency capabilities for detecting radiological and nuclear materials onboard small vessels and communicating information to shore-based experts for technical reachback.

LLNL provided technical expertise in support of the New START agreement, signed by U.S. President Barack Obama and Russian President Dmitry Medvedev on April 8, 2010. (Photo courtesy of U.S. Department of State and White House; photographer: Chuck Kennedy.)



Awards for Radiation Detection Technologies

Two advances in radiation detection received 2010 R&D 100 Awards. The Statistical Radiation Detection System (SRaDS) is a novel software application that enables rapid and accurate discrimination of plutonium and uranium from nonthreatening radioactive materials and can be readily integrated into existing gamma detection systems, including those used at border crossings. The new scintillator material—europium-doped strontium iodide—makes possible high-resolution gamma-ray spectroscopy in small instruments suitable for field use or covert operations.

Roadmap for Cyber-Security Policy

Laboratory researchers are developing advanced technical approaches to provide enhanced situational awareness on large computer networks. In concert with these efforts, LLNL has partnered with Georgetown University to examine the interlinked policy, legal, and technical issues involved in securing cyberspace in an increasingly networked world. In March, the two organizations hosted a workshop for participants in the areas of policy, law, technology, and private industry to debate these issues and explore potential solutions to current and future cyber-security challenges. A report titled *Reboot: Defining Paths to Cyber Policy, Law and Technology Solutions* lays the foundation for a roadmap for expanded research, national dialogue, and government–private sector partnership on critical cyber-security issues.

Aviation Security

In response to the December 25, 2009, terrorist attempt to destroy Northwest Airlines Flight 253 and the subsequent presidential directive, LLNL is applying its high-explosives expertise to aviation security. As part of the National Explosive Engineering Security Science Center (a partnership of Lawrence Livermore, Los Alamos, and Sandia national laboratories), we are using computer modeling together with sub- and full-scale experiments to determine the catastrophic damage threshold for aircraft as a function of explosive amount, location, and flight conditions. Advances in nondestructive evaluation and x-ray imaging are providing the scientific basis for next-generation



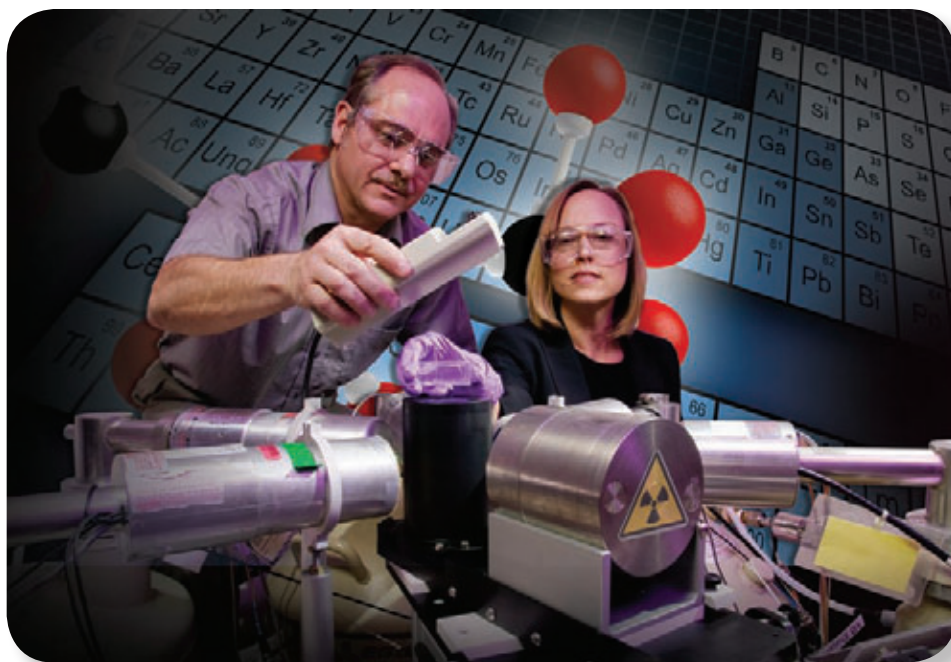
LLNL experts are performing high-fidelity simulations of a projectile hitting a plate of transparent ceramic armor, which creates an intricate web of cracks within but does not penetrate the material.

explosives screening technology and informing the development of commercial detection systems. In FY2010, our scientists and engineers characterized the improvised explosive performance and detection signatures for high-priority aviation threats and completed a vulnerability assessment of narrow-body aircraft to improvised explosives. LLNL also cochaired the Aircraft Vulnerability Working Group under the DOE–DHS Aviation Security Enhancement Program.

Behavior of Granular Materials

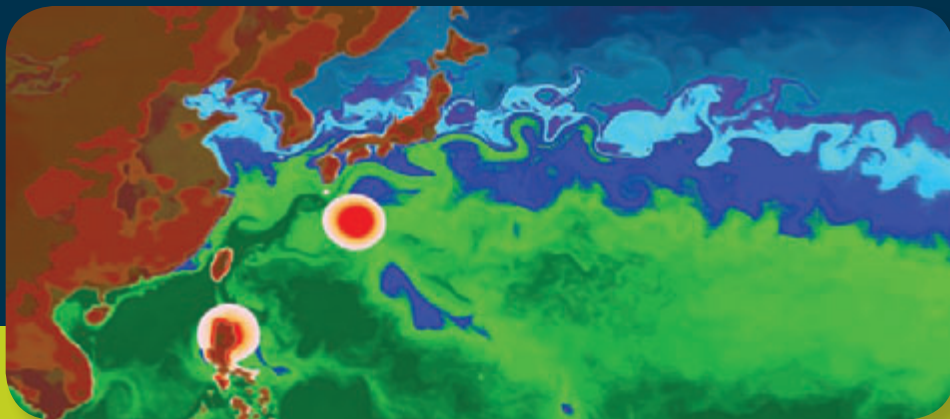
Granular materials such as sand exhibit unusual properties under loading, behaving like either fluids or solid matter. We are using sophisticated techniques such as atomic force microscopy to measure the strain rate and fracture

properties of individual grains of material, performing shock compression experiments, and using the results together with first-principles physics to develop and improve predictive simulation models. In the first year of this three-year effort, we focused on ductile (rather than brittle) materials, generating baseline data to test the overall effectiveness of the codes. For DHS, we are building models to simulate how rocks and soils respond to loads generated by seismic events or explosives, knowledge directly applicable to the protection of critical infrastructure. For the Department of Defense, we are using these models to study in detail how transparent ceramic armor, used as a protective windshield on tanks and other military vehicles, behaves when hit by a projectile such as a bullet.



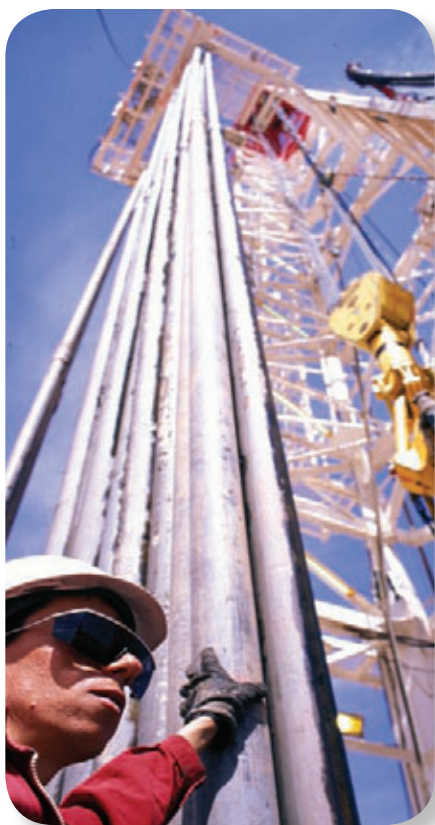
Small, high-resolution radiation detectors are now possible, thanks to a new scintillator material developed by Laboratory researchers.

LLNL researchers at the Program for Climate Model Diagnosis and Intercomparison led a multi-institutional effort to simulate the formation of tropical storms at much finer resolution and using higher fidelity physics than what had previously been considered the state of the art.



ENERGY & ENVIRONMENT

Helping meet the nation's and the world's ever-increasing demand for energy while confronting climate change and promoting environmental sustainability



Livermore scientists are partners in a plant-scale demonstration of carbon sequestration at the In Salah site in Algeria.

The geopolitics of energy are influenced greatly by the fact that most of the principal energy consumers are not the principal energy producers. LLNL applies its range of scientific, engineering, and computational resources to develop innovations to reduce the environmental impact of fossil fuels, expand the use of alternative energy resources, and create new energy sources for a sustainable future. The Laboratory also evaluates the implications of energy use decisions, improves the physics models and quantifies uncertainties in climate simulations, and investigates the processes that influence global climate and drive climate change, including the effects of human activities.

Carbon Capture and Sequestration

In a new project begun this year, LLNL has partnered with the University of Illinois and Babcock & Wilcox to develop a synthetic version of the naturally occurring enzyme carbonic anhydrase that can be used to efficiently capture carbon dioxide (CO_2) from industrial plant emissions. Successful development of this enzyme mimic would make possible cost-effective carbon capture systems for existing and new power plants and other industries. The Laboratory is also a partner with BP, Statoil, Sonatrach, and DOE in studying carbon sequestration at the In Salah site in Algeria. In FY2010, we developed a hydro-geomechanical model that reconciled CO_2 mass injection

fluxes and injection pressures with satellite-measured data on land surface deformation, enabling an improved understanding of reservoir properties and the fate of the injected CO_2 plume. In addition, experiments in which reservoir lithological samples were exposed to CO_2 under in situ temperature and pressure were used to develop a geochemical model to predict mineral trapping of CO_2 long after injection ceases. Also in FY2010, the Laboratory entered into several collaborations with China that will give researchers invaluable field experience in developing and deploying carbon capture and sequestration systems.

Underground CO_2 Monitoring

Electric resistance tomography (ERT), a technique originally developed to track the movement of contaminants in near-surface groundwater, has been successfully applied to monitor CO_2 pumped deep underground for sequestration. The ERT system was installed in two monitoring wells more than 10,000 feet deep to follow the movement of a plume of CO_2 injected underground at the Cranfield oilfield near Natchez, Mississippi. Changes in CO_2 concentration cause changes in resistivity, allowing ERT to image the electrical resistivity distribution associated with the underground plume. ERT monitoring of a sequestration reservoir would detect CO_2 leakage long before it nears the surface or any overlying aquifers.

Biofuel Combustion Chemistry

An international team, including researchers from LLNL and Sandia/California, conducted the first-ever study of the combustion chemistry of the compounds that constitute typical biofuels such as ethanol and biodiesel. A combination of laser spectroscopy, mass spectrometry, and flame chemistry modeling was used to investigate the decomposition and oxidation mechanisms of various biofuels and the formation of harmful or toxic emissions. The researchers discovered that biofuel combustion chemistry is much more complex than the combustion of petroleum-based fuels. This discovery highlights the need for a better understanding of the key elements of biofuel combustion before informed decisions can be made about the development and use of next-generation alternative fuels.

Special Award for PCMDI

The American Meteorological Society honored LLNL's Program for Climate Model Diagnosis and Intercomparison (PCMDI) with a special group award for "leadership in implementing, maintaining and facilitating access to the Climate Research Program's CMIP3 [Coupled Model Intercomparison Project Phase 3] multi-model dataset archive, which led to a new era in climate system analysis and understanding." PCMDI develops methods and tools for systematically comparing the general circulation models that simulate global climate, provides facilities for storing and distributing terascale data sets from model simulations, and analyzes the causes behind differences in results produced by the increasingly complex models.

Semitruck Fuel Efficiency

LLNL partnered with Navistar Inc., the National Aeronautics and Space Administration (NASA) Ames Research Center, the U.S. Air Force, and private industry to develop and test devices for reducing the aerodynamic drag of semitrucks. Simulations with the Laboratory's advanced computational fluid dynamics codes identified critical drag-producing regions around semitrucks, such as the trailer base, underbody, and gap between the tractor



From left, LLNL's Tomás Díaz de la Rubia and Julio Friedmann sign a memorandum of understanding with Xu Shisen, chief engineer for the Thermal Power Research Institute in China, on October 9, 2009, paving the way for LLNL to partner in a Chinese carbon sequestration demonstration project.

and trailer. Tests were conducted in the NASA Ames wind tunnel (the world's largest) using a full-size semitruck and commercially available and prototype drag-reduction devices. LLNL scientists estimate that widespread use of properly placed drag-reduction devices could increase semitruck fuel efficiency by as much as 12 percent, for an annual reduction in diesel fuel usage of 3.4 billion gallons and a yearly cost saving of \$10.2 billion.

Gulf Oil Spill Emergency Response

From April through August, more than two dozen Laboratory engineers and scientists served shifts at BP's Houston headquarters, with scores more at LLNL

providing reachback assistance, as part of a DOE/tri-lab team helping to stem the massive Deepwater Horizon oil spill. They drew on Laboratory expertise in fluid mechanics, diagnostic instrumentation, and signal and image processing to estimate the volume of gushing oil and assess the condition of the blowout preventer and the integrity of the well. LLNL researchers helped develop a gamma-ray system to provide images of the failed blowout preventer, the first time the diagnostic technique had been used successfully at such a depth underwater. The tri-lab team also provided technical "red teaming" of proposals and designs by BP engineers for halting the oil spill and capping the runaway well.

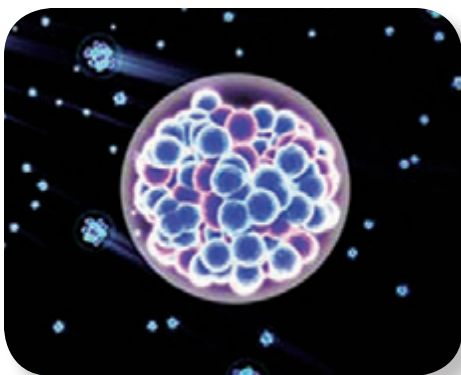


Based on fluid dynamics models and full-scale tests at the NASA Ames wind tunnel, Livermore scientists estimate that drag-reduction devices could improve semitruck fuel efficiency by 12 percent.

SCIENCE & TECHNOLOGY

Advancing the frontiers of science and developing the technological capabilities needed to solve problems of national and global importance

Element 117 is the sixth superheavy element discovered by a team of researchers from LLNL and the Joint Institute of Nuclear Research in Dubna, Russia.



The Dynamic Transmission Electron Microscope is unique in its ability to capture images of nanometer-size particles with nanosecond exposure times.

Science and technology are key to overcoming many of the most serious challenges facing the nation and the world. At LLNL, we harness our unique experimental facilities, world-class computing resources, and multidisciplinary expertise for scientific discovery and to advance the state of the art in technology.

Discovery of Element 117

The newest superheavy element, ununseptium or element 117, was discovered by an international team of scientists from six institutions in Russia and the United States. Element 117's existence was established from decay patterns observed following bombardment of a berkelium target with calcium ions at the Joint Institute of Nuclear Research's U400 cyclotron in Dubna, Russia. The experiment depended on dedicated accelerator time and special detection facilities at Dubna, unique isotope production and separation

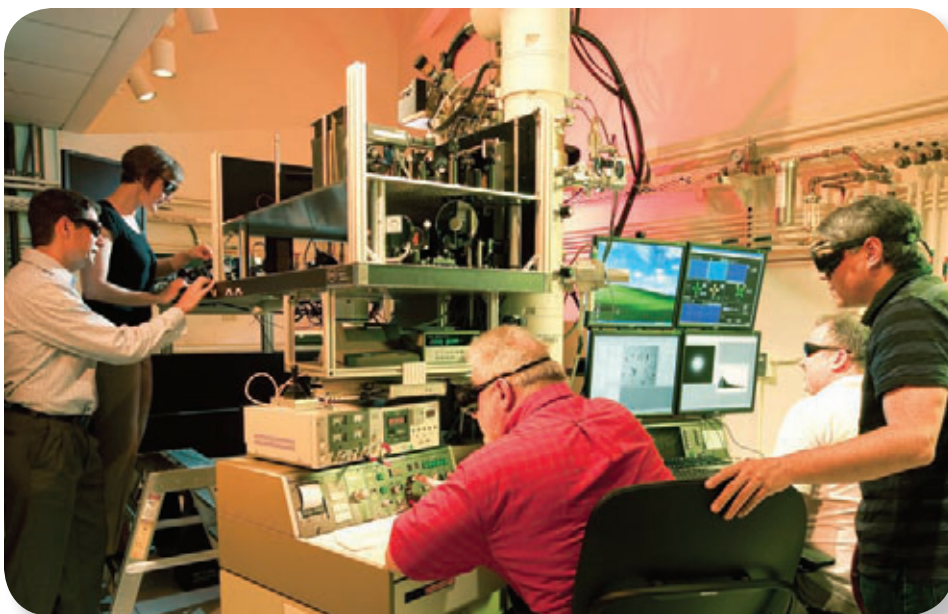
facilities at Oak Ridge National Laboratory, and distinctive nuclear data analysis capabilities at LLNL. The discovery of element 117 brings researchers closer to the predicted "island of stability" of superheavy elements and raises the total of new elements discovered by the Dubna–Livermore team to six (elements 113 through 118).

DTEM Imaging Advance

Using a new imaging technique on the Dynamic Transmission Electron Microscope (DTEM), researchers from LLNL and the University of California at Davis were able to capture images of nanoparticle catalysts with unprecedented spatial and temporal resolution. DTEM can record electron micrographs with a 15-nanosecond exposure time, and the addition this past year of an annular dark field aperture makes it possible to time-resolve images of particles as small as 30 nanometers in diameter. This accomplishment opens the door to future work that could greatly improve catalyst efficiency in processes crucial to the world's energy security, such as petroleum catalysis and catalyst-based nanomaterial growth for next-generation rechargeable batteries. In August, DTEM received a 2010 Innovation Award from *Microscopy Today* as one of the year's 10 best new products and methods across the entire field of microscopy.

Big Results from Nanoshocks

Laboratory researchers demonstrated an ultrafast laser-based technique, dubbed "nanoshocks," for studying the behavior of materials at otherwise inaccessible temperatures, pressures, and timescales. Conducted in a diamond anvil cell, the technique enables scientists to study shock behavior in tiny samples such as thin films or other systems with microscopic



dimensions (a few tens of micrometers). Because the timescale is so short, the results can be directly compared with molecular dynamics simulations, yielding insights into fundamental physical and chemical processes and improving scientific understanding in areas ranging from detonation phenomena to the interiors of planets.

An “Impossible” Calculation

At the Supercomputing 2009 Conference, a team of LLNL scientists and an IBM researcher announced a breakthrough in the field of scientific simulation. By using an innovative approach—called heterogeneous decomposition—to partition the use of massively parallel supercomputers in a novel way, the team was able to speed up the calculation of long-range forces (e.g., gravity, electromagnetism) to an extent that some experts had deemed “impossible.” The new BlueGene/P node technology developed for the Laboratory’s Dawn and Sequoia supercomputers made possible this new approach, which has far-reaching implications for future code development and the ability of these next-generation supercomputers to efficiently run complex physics models. Also at that conference, HPCWire, a news service dedicated to supercomputing, presented the Hyperion Project with a “Best HPC Collaboration between Industry and Government” award. Funded by NNSA’s Advanced Simulation and Computing program, Hyperion is a collaboration of LLNL and 10 industrial partners to advance next-generation Linux cluster supercomputers.

Greater Heights for Unclassified Computing

LLNL’s new Sierra supercomputer is the most powerful high-performance computing resource available for unclassified research. Research areas requiring Sierra’s number-crunching power include climate and atmospheric modeling, supernova and planetary science, materials and strength modeling, laser and plasma physics, and biology and life sciences. With a peak speed of 261 teraflop/s, the system will support Laboratory Directed Research and Development, Grand Challenge, and other unclassified research efforts. When fully available for use in early FY2011, Sierra will boost LLNL’s unclassified

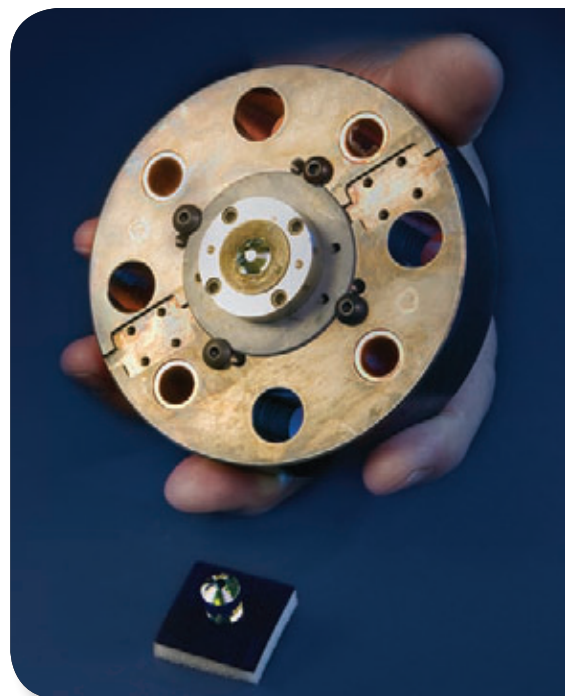
computing resources from 440 teraflop/s to more than 700 teraflop/s.

New Hominid Species

The Laboratory was part of an international team that discovered a new species of hominid, *Australopithecus sediba*, thought to be at least 2 million years old. The fossil, found in an area of South Africa known as the “cradle of humankind,” was exceptionally well preserved, affording unique insight into the period when the earliest members of the genus *Homo* evolved. LLNL’s Center for Accelerator Mass Spectrometry was used to provide a paleo-ruler to track the evolution of the landscape from where the fossils were originally deposited to where they were found in the present day. This information gives researchers valuable clues to the type of landscape our earliest ancestors inhabited.

Possible Cometary Origin of Life

New research by Laboratory scientists showed that comets crashing into Earth millions of years ago could have produced



A diamond anvil cell is used for a new ultrafast, laser-based technique, called “nanoshocks,” for studying materials at extreme pressures, temperatures, and timescales.



Measurements made at the Center for Accelerator Mass Spectrometry helped characterize the environment inhabited by a newly discovered species of hominid, *Australopithecus sediba*.

SCIENCE & TECHNOLOGY



LLNL scientists are gathering new data on the opacity of helium under conditions that exist in white dwarfs, formed when a star like our Sun ends its life by shedding its outer layers of gas. The information is helping researchers determine more accurately the age of such stars. (Photo courtesy of NASA/JPL/STScI/AURA.)

launched in mid-February to study the Sun in unprecedented detail. A team of LLNL researchers provided the state-of-the-art reflective multilayer coatings, deposited with a thickness precision on the order of an atomic diameter, for the curved mirrors inside the AIA's array of four telescopes, which image extreme ultraviolet light emissions from the Sun.

amino acids, the building blocks of life. Using molecular dynamics simulations, the LLNL team studied shock compression in a prototypical astrophysical ice mixture up to extremely high temperatures and pressures, similar to a comet crashing into Earth. They found that as the material decompresses, protein-building amino acids are likely to form. The scientists thus posit that concentrations of prebiotic organic species could have been "shock synthesized" on Earth from materials originating in the outer regions of space.

New Light on Helium

An international team, including LLNL, used the OMEGA laser at the University of Rochester's Laboratory for Laser Energetics to obtain new data about the opacity of helium at the extreme conditions that exist in the atmospheres of white dwarf stars. White dwarfs are thought to be the final evolutionary state of all stars whose mass is not high enough for them to die as supernovae (more than 97 percent of the stars in our galaxy). The age of a white dwarf is connected with its luminescence, which decreases as it cools. The new data will allow researchers to more accurately

model the relationship between observed luminosity and the age of the star and provide clues about the formation history and age of the Milky Way.

Peptide Control of Crystal Growth

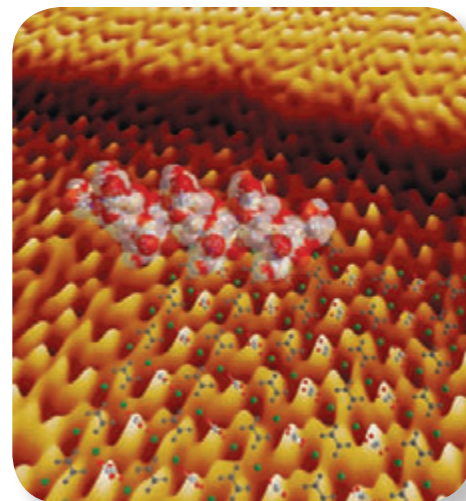
Research by LLNL and partners provided insights into how living organisms manipulate the shape of growing crystals, such as occurs in the growth of bones and teeth. Specifically, using advanced atomic force microscopy, the researchers were able to watch peptides (small protein fragments) adhere to the surface of a growing crystal and, depending on conditions, speed up, slow down, or completely stop the crystal's growth. Understanding how organisms regulate the growth of inorganic minerals is important in developing treatment strategies, for example, to speed bone growth for shattered limbs or prevent the formation of gallstones or kidney stones.

Multilayer Mirrors for NASA Spacecraft

Laboratory-developed precision multilayer mirrors are part of the Atmospheric Imaging Assembly (AIA), one of three instruments onboard NASA's Solar Dynamics Observatory, which was

Nanotechnology for Biodetection

In a boost for public health and biosecurity, Laboratory scientists have developed two new miniature biodetection devices. The heart of the first device, developed with colleagues at Lawrence Berkeley National Laboratory's Molecular Foundry, is a flow-through, silicon-based



In this simulation, peptides adhere to the surface of a crystal where, depending on conditions, they can speed up, slow down, or completely stop the crystal's growth.

photonic crystal that can detect small numbers of nanometer-scale viruses in real time. The tiny crystal (7 micrometers long) is made of virus-size pores etched into a silicon slab, which is connected to two waveguides, and can be integrated with microfluidics and signal transducers to create a biodetector on a chip. The diameter of the pores can be tuned to detect viruses of a specific size and exclude other particles, such as bacteria and dust. The second device is the Lawrence Livermore Microbial Detection Array (LLMDA). With 388,000 probes that fit on a 2.5- by 7.5-centimeter glass slide, the device can detect or identify more than 2,000 viruses and 900 bacteria within 24 hours. This past year, LLMDA confirmed an unexpected finding of a benign pig virus in a widely used rotavirus vaccine, demonstrating the value of the technology for biological product safety as well as disease diagnosis and bioterrorism detection. The device also was used to assist the Marine Mammal Center (Sausalito, California) in diagnosing diseases afflicting California sea lions and harbor seals.

Award-Winning Technologies

Six technologies developed by Laboratory researchers and partners received R&D 100 Awards: an adaptive optics system for cellular-level retinal imaging, carbon nanotube membranes for improved water purification, a diagnostic instrument for measuring the pulse-by-pulse energy of an x-ray free-electron laser beam, an ultrafast imager, a new scintillator material, and a statistical software system

for better radiation detection. LLNL's Environmental Sampler Processor and LLMDA received, respectively, outstanding partnership and outstanding technology development awards in the Federal Laboratory Consortium's Far West Region competition. In addition, the Argus II retinal implant, developed by LLNL and partners, was honored with a *Popular Mechanics* 2010 Breakthrough Award.

Entrepreneurs in Readiness

A unique approach to technology transfer, rolled out by LLNL in the last year, is starting to bear fruit. The Entrepreneurs in Readiness program brings together serial entrepreneurs (those who have launched more than one successful start-up company) with Laboratory technologies ripe for commercialization. Currently, we are working with eight Silicon Valley entrepreneurs to develop various technologies into marketable products. One example involves the use of Livermore's ultrawideband radar technology to monitor brain injury patients for hematomas (pooling of blood between the brain and skull). The entrepreneur investigated the potential market and determined the required form, functionality, and cost. With maturation funding provided by LLNL's Industrial



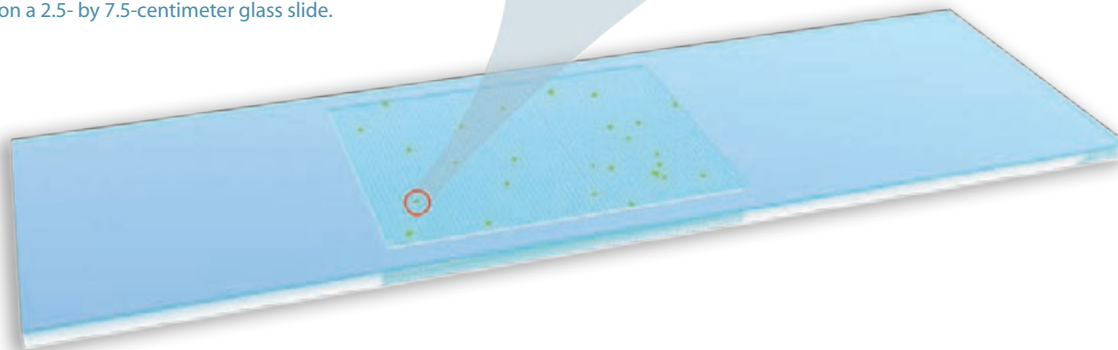
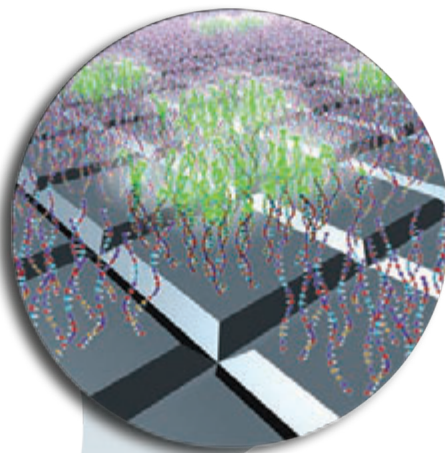
The Laboratory's Entrepreneurs in Readiness program facilitated development of this prototype ultrawideband radar device for detecting subcranial hematomas.

Partnerships Office, the entrepreneur and Laboratory inventor worked together to build a prototype device, which is currently being used in pre-clinical human trials at the University of California at Davis School of Medicine. In the U.S. alone, an estimated 1.3 million people suffer traumatic brain injuries annually, resulting in 50,000 deaths and 100,000 disabilities. A device that can continuously and noninvasively monitor for hematomas could reduce the deaths and suffering of thousands of people.

Industrial Partnering Statistics

LLNL received 54 U.S. patents, filed 122 patent applications, and submitted 160 records of invention in FY2010. We also signed 13 new cooperative research and development agreements with industrial partners and 24 new commercial licenses for Laboratory-developed technologies and software. Licensing and royalty income for the year totaled \$8.5 million, representing well over \$400 million in annual sales of products based on LLNL technologies.

A DNA microarray allows scientists to identify thousands of sequenced viruses and bacteria at the same time. Squares containing different segments of DNA or RNA are arrayed in rows and columns on a 2.5- by 7.5-centimeter glass slide.



SAFETY, SECURITY, & ENVIRONMENT

Demonstrating safety and security excellence and sustainable environmental stewardship in all Laboratory activities

The Laboratory has strengthened its collective commitment to safety, security, and the environment. Best practices are being implemented throughout LLNL, driven both from the top down and from the bottom up. Our operations meet high standards in security and implement sustainable practices. We ensure the safety of employees and the public by taking active measures to prevent accidents and prudently manage risks.

Effective Safety Practices

In April, NNSA approved our Integrated Safety Management System (ISMS), which establishes the processes by which we integrate environment, safety, and health requirements into work planning and controls. The approval followed a yearlong review that examined the safety of our programs and processes and evaluated employees' understanding of and commitment to safe work practices. LLNL was one of the first sites to undergo a review of its ISMS program under the higher standards now in place. Exemplifying our commitment to work safety was the Global Security Principal

Directorate's receipt of a National Safety Council award for one million employee-hours worked without an occupational injury or illness involving days away from work.

Attention to Hazards Control

Concerted ongoing efforts in hazards control are providing for improved worker safety through programs in industrial hygiene, industrial safety, and biological safety. In FY2010, we completed 28 of 29 scheduled corrective actions as part of our Chronic Beryllium Disease Prevention Program and revised the closure date for the last item to November with Livermore Site Office concurrence. As part of an Industrial Hygiene Baseline Project, teams assessed a total of 171 buildings for chemical, biological, and others hazards. Findings are being addressed, with the survey

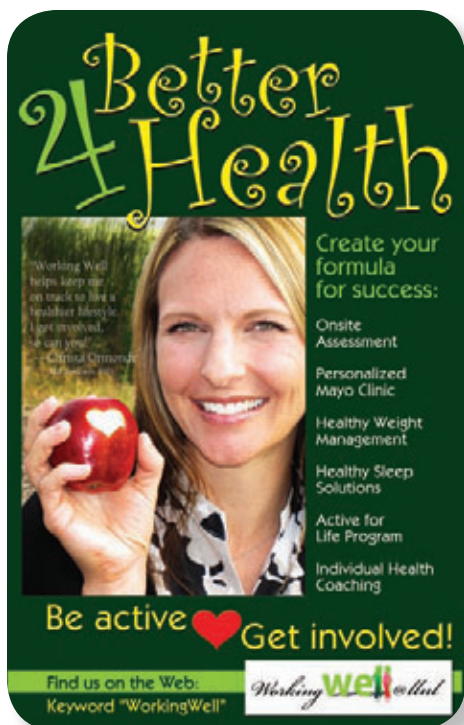
results organized into similar exposure groups to facilitate best practices in hazards management. The gathered data reside in a new industrial hygiene database that will improve our ability to perform and document future hazard assessments, gather and analyze data, formulate recommendations, and share information across the Laboratory. In addition, we are implementing Occupational Health and Safety Assessment Series (OHSAS) standard 18001, which provides a framework to help control occupational health and safety risks.

Tops in SWAT and Cyber Security

LLNL enhanced its security operations in FY2010 by building on improvements made over the last several years in the areas of physical security, protective force, classified material protection,



Programs in hazards control are improving worker safety (left); LLNL's Special Response Team took top honors in a major SWAT competition (top right); a canine member of LLNL's security force enjoyed the Laboratory's annual Safety Fair (bottom center); and the Global Security Principal Directorate received a National Safety Council award for one million hours of safe work (bottom right).



WorkingWell@LLNL includes the Laboratory's highly successful Healthy Heart Program, access to the Mayo Clinic Embody Health personal health management Web portal, and incentives (including awards) for employees who adopt healthy lifestyles.

cyber security, and program management. Notably, our Special Response Team took first place in the Connecticut SWAT Challenge, the nation's second largest special weapons and tactics (SWAT) competition. LLNL earned top scores in five of the seven challenges in this three-day event, which drew 40 teams and 1,000 officers from across the country. In addition, a team of computer security specialists from LLNL, Pantex Plant, and the Defense Information Systems Agency won first place in a national laboratory cyber competition held at the Tracer FIRE 2 Workshop. Eleven multi-lab teams competed for two days testing their skills in malware, reverse engineering, network and host forensics, cryptography, social engineering, and hidden data discovery.

WorkingWell@LLNL

In May, the WorkingWell@LLNL health initiative was launched to help employees enhance their health by improving lifestyle habits and managing risk factors for chronic conditions. The program provides

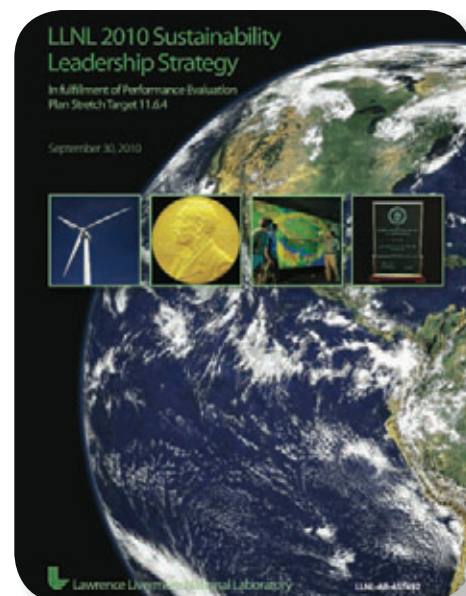
recognition and rewards to employees who have already established good health habits or are managing risk factors and taking steps to adopt a healthier lifestyle. It also gives employees, their spouses, and adult dependents access to the Mayo Clinic's interactive personal health management Web portal, through which they can complete the Mayo Clinic Health Assessment and receive personalized reports of health strengths and recommendations for action.

Leadership in Sustainable Practices

We developed the *LLNL 2010 Sustainability Leadership Strategy* to guide our efforts to implement current best practices and, in concert with our programmatic thrusts, develop technologies and new best practices that enhance the energy and environmental security of our nation. Focus areas for sustainability best practices include energy efficiency and renewables, water conservation, waste management, procurement practices, and high-performance sustainable buildings. As an example of these efforts, we are developing solutions to reach a 2015 goal of reducing energy intensity by 30 percent and water usage by 15 percent compared to baseline numbers. Our sustainability strategy builds on ISO 14001 certification for our Environmental Management System, achieved in FY2010, which provides a systematic approach to identifying the environmental impact of activities, setting goals to lessen the impact, and accomplishing those objectives.

Awards for Going "Green"

This past year, our Terascale Computing Facility received a Leadership in Energy and Environmental Design (LEED) Gold certification under the U.S. Green Building Council rating system and another facility was certified Silver. Award-winning features include individualized air-flow management for each of the 24,000-square-foot computer rooms, higher air temperature in the computer rooms and higher water temperature in the cooling system, and automated electrical usage to reduce off-hours power consumption in offices. Two Laboratory projects also received Environmental Stewardship Awards from NNSA; one avoided the generation



The *LLNL 2010 Sustainability Leadership Strategy* advances national goals established by Presidential Executive Orders to implement and further improve sustainable practices. It describes the actions we are taking to provide sustainability leadership within the NNSA weapons complex.

of thousands of pounds of waste and the other reduced site-wide use of potable water.

Emergency Readiness and Response

The Laboratory completed a multiyear effort to increase readiness in the event of an emergency, including major upgrades to equipment and improvement of emergency preparedness plans and procedures. As part of a more rigorous emergency exercise program, we conducted 13 drills in high-hazard facilities and held the security-related Annual Fall Participation Exercise. The exercises benefited from steps to increase realism and a focus on the full integration of Laboratory and outside-agency field emergency elements. In addition to increasing our emergency readiness, we provided analytical, operational, and reachback emergency response support for other events, including the State of the Union address, the Rose Bowl and Bowl Championship Series football games, the Iceland volcanic eruption, and the World Cup soccer tournament.

As LLNL Director George Miller stated at the Project Management Institute's award ceremony, "NIF's success can be attributed to its excellent team of scientists, engineers, technicians, and support personnel; to the rigorous application of best-practice project management standards, processes, and techniques; and to highly productive teamwork with NNSA, DOE, and our many partners around the world."



MANAGEMENT & OPERATIONS

Managing the workforce, improving work processes, streamlining and standardizing business practices, and achieving cost efficiencies in operations

Excellence in management, business, and operations and attention to the needs of the workforce complement LLNL's outstanding performance in science and technology. Initiatives to standardize work processes and apply value-adding tools for managing projects are bearing fruit. We continue to leverage the expertise of the partner organizations of our management contractor, Lawrence Livermore National Security, LLC (LLNS), to identify opportunities for improving the efficiency and cost effectiveness of our operations.

Project Management Award for NIF

Citing groundbreaking technical achievement and exemplary project management, the Project Management Institute (PMI) named NIF as 2010 Project of the Year in a ceremony in Washington, D.C. The prestigious award recognizes the year's most innovative and successful project. NIF was honored for "pushing beyond the state of the art" to successfully complete the \$3.5 billion project. Gregory Balestrero, president and chief executive officer of PMI, lauded NIF as "a stellar

example of how properly applied project management excellence can bring together global teams to deliver a project of this scale and importance efficiently."

New Faces at the Laboratory

With work efforts expanding in many mission areas, LLNL is seeking to hire several hundred new engineers, computer scientists, chemists, and physicists. To help meet this need, the Laboratory held its first Accelerated Candidate Hiring Event, for computer scientists, in April, with other such events planned for the future. Pre-screened candidates were introduced to selected projects, met potential managers and colleagues, and received a hiring decision the same day as their interview. New faces were also among the seven senior management positions filled in 2010. Most notably, Tom Gioconda, a retired Air Force Brigadier General who also held senior management positions at NNSA and Bechtel National, became Laboratory deputy director in August following the departure of Steve Liedle, who took a senior position with Bechtel National.

Compensation Program Improvements

LLNL restructured its decades-old science and engineering classification

Director George Miller welcomes newly appointed LLNL Deputy Director Tom Gioconda to the Laboratory. Gioconda brings to the assignment considerable management experience and in-depth understanding of the Laboratory's principal sponsors, missions, and operations.



model through a process that engaged Laboratory managers down to the supervisor level and included multiple opportunities for employee input and feedback. The new Professional Scientific and Technical Staff classification structure includes job classification levels and descriptions, providing a clearer definition of roles and responsibilities, greater clarity of career progression, and a stronger link to market salaries.

Contractor Assurance System

The Laboratory's Contractor Assurance System (CAS) demonstrated that it met NNSA-defined criteria to be considered "functional." CAS is an integrated system of tools and processes for managing requirements and standards, tracking issues and their resolution, collecting performance data, and continuously improving the assessment process. The system passed rigorous internal and external assessments that found it more than 75 percent of the way to being "fully functional." A review by the Livermore Site Office (LSO) found that the "LLNL CAS is sufficiently mature that LSO can begin to adjust its oversight methods immediately."

Improved Financial Management System

LLNL implemented a Performance Measurement Baseline (PMB) financial and project management system and, in its first major application, used it to successfully manage some \$450 million of (indirect) funding for operational support. Based on components of the Earned Value Management System, PMB is a best-practices approach that includes multilevel work-scope-defined cost and schedule baselines to clarify how much money is to be spent in areas and tracks project performance. Baseline tools, systems, and processes continue to be enhanced to expand use of PMB across the Laboratory.

Complex Consolidation at LLNL

As part of NNSA's Weapons Complex Consolidation, we are reducing the footprint of active Laboratory facilities by 2 million square feet. Our Strategic Space Consolidation project made excellent progress in FY2010 with the closure of 11 facilities. Since the effort began in FY2008, we have shut down or demolished more than 821,000 gross



The High-Performance Computing Center will be a flagship facility of the Livermore Valley Open Campus.

square feet of space. We are also removing from LLNL the special nuclear material that requires the highest level of protection. At the end of FY2010, more than three-quarters of the material had been shipped to other NNSA sites. The deinventory, which began in October 2006, is on track to be completed in 2012.

Reachback to LLNS Partners

The LLNS Board of Governors and its committees provided oversight to the Laboratory in critical areas related to mission and mission support activities through board meetings, participation in external review committees, and the conduct of Functional Management Reviews. This year, LLNS held 12 such

reviews on topics ranging from CAS to work for others. In some cases, these reviews resulted in LLNL importing commercial best practices; in others, they validated the effectiveness and successful application of new processes and procedures.

Livermore Valley Open Campus

Planning for the Livermore Valley Open Campus (LVOC) advanced in FY2010 with the preparation of a Development Options Report. The LVOC concept calls for an open campus on a 110-acre parcel on the eastern edge of the Lawrence Livermore and Sandia/California sites that will provide expanded opportunities for the two laboratories to partner in research and development activities with industry and academia. The report describes a vision for an open campus anchored by user facilities for high-energy-density physics research, high-performance computing, and transportation energy research. Flad Architects (Madison, Wisconsin) was engaged to prepare several design options for staged development of LVOC.

Principal Associate Director Parney Albright gives prospective LLNL computer scientists an overview of projects in global security at our first Accelerated Candidate Hiring Event. A former assistant secretary at the Department of Homeland Security, Albright joined the Laboratory in FY2010.



Videoconferencing allows students in the classroom to talk directly with LLNL scientists and virtually tour Laboratory facilities.



COMMUNITY CONNECTIONS

Supporting local communities through science and math education and charitable giving

At the Laboratory's 14th annual Tri-Valley Science and Engineering Fair, 305 students presented their projects to local-area scientists serving as judges and competed for sweepstakes honors and other prizes.

The Laboratory strives to be a valued and contributing member of the community, with an emphasis on outreach in science, engineering, and math education. LLNL employees also generously support local communities through charitable giving and volunteer efforts. In addition, the LLNS gift program provides a direct investment in community science and math education and cultural arts.

Scientists in the Classroom

In collaboration with the San Ramon Valley Unified School District, we launched a pilot educational program called Scientists in the Classroom. In this pilot, videoconferencing enabled two classes, one a 7th-grade science class and the other an accelerated biology class for 11th and 12th graders, to “virtually” tour LLNL’s Center for Accelerator Mass Spectrometry (CAMS) and talk in real time with Laboratory scientists about CAMS, the research conducted there, and how to prepare for a career in science. The program was a hit with both students and teachers and is being evaluated for expansion to include tours of additional LLNL research facilities by students from schools throughout the Tri-Valley area and beyond.

Saturday Lecture Series

LLNL’s popular Science on Saturday lecture series again played to packed houses. More than 6,000 people attended a total of 12 lectures, which were held in both Livermore and Tracy. Laboratory researchers partnered with local science teachers in discussions and



demonstrations about fighting antibiotic resistance, imaging other solar systems, understanding climate change, and harnessing fusion energy.

Annual Science Fair

More than 300 middle- and high-school students from nearby schools presented over 200 projects at the 14th annual Tri-Valley Science and Engineering Fair sponsored by LLNL. More than 150 local scientists and engineers, the majority of whom were from the Laboratory, and area science teachers served as judges. Several of the fair's sweepstakes winners went on to win awards at the Intel International Science and Engineering Fair and the California State Science Fair.

Teacher Research Academy

A total of 37 practicing science teachers and students currently enrolled in teaching credential programs completed research internships through LLNL's Teacher Research Academy. The teachers worked as members of Laboratory research teams in a variety of disciplines including biotechnology, physics, and engineering, where they gained hands-on experience in how scientific research is conducted to solve problems. A study of the Teacher Research Academy program completed in 2010 by faculty from the University of California at Davis School of Education found clear evidence that completing a research internship



Laboratory employees participate in the Livermore Rodeo's family night (top left) and the American Cancer Society's Relay for Life (left) and Daffodil Days (above).

significantly improved the teachers' ability to effectively teach science when they returned to the classroom.

Record HOME Donation

The Laboratory's HOME (Helping Others More Effectively) campaign is one of the region's most generous annual charity drives. In FY2010, LLNL employees, along with LLNS, raised more than \$3 million for nonprofit organizations in

the Tri-Valley, San Joaquin Valley, and greater San Francisco Bay Area. The total contribution of \$3,026,151 was the largest amount ever raised during the HOME campaign's 35-year history and the largest contribution of any laboratory in the DOE complex.

Holiday Outreach

LLNL employees helped brighten the holiday season for 75 families in need. Families from Livermore, Tracy, Modesto, and Ceres were sponsored by hundreds of employees from across the Laboratory who donated toys, clothing, and other gifts chosen specifically to meet the individual family's needs. The volunteer effort was organized with the help of local school districts.

Relay for Life

Laboratory employees joined in the American Cancer Society's annual Relay for Life, held in June at the Livermore High School track. Of the 76 relay teams that participated in the two-day continuous run, LLNL's 54-member squad was the largest and raised more than \$11,000 in donations for cancer research and programs that benefit cancer patients.



Laboratory employees donate funds to area nonprofit organizations through the annual HOME campaign; in FY2010, more than \$3 million was raised.

WORKFORCE

Recognizing outstanding performance and accomplishments

A workforce of exceptionally talented, skilled, and dedicated employees is needed to meet the challenges of LLNL's mission. The many honors and awards received by Laboratory employees this past year are clear recognition of the excellence of our people, their contributions to their professions, and their impact on the security and economic competitiveness of the nation.

E. O. Lawrence Award

Physicist Omar Hurricane received an E. O. Lawrence Award for breakthrough work in nuclear weapon physics, resolving a 40-year-old anomaly that was one of the factors driving the need for nuclear testing.

Jefferson Award

Ed Moses, principal associate director of NIF and Photon Science, was a regional winner of a Jefferson Award for his educational outreach efforts. Moses



regularly volunteers time to engage students and the general public on physics, lasers, fusion energy, and how science can be used to address many of the challenges facing society. Considered a "Nobel Prize" for public service, the awards, named for Thomas Jefferson, were cofounded in 1972 by Jacqueline Kennedy Onassis to honor volunteerism and community outreach throughout the nation.

Women's Hall of Fame

Engineer Lisa Poyneer was inducted into the Alameda County Women's Hall of Fame in the science category. Poyneer is an internationally recognized expert in adaptive optics and signal processing. Her research is central to the development of the Gemini Planet Imager, which will be deployed on the Gemini South telescope in Chile to image and characterize planets outside our solar system. Poyneer joins seven other current and past LLNL employees selected for the Alameda County Women's Hall of Fame.

Newcomb Cleveland Prize

Physicist Bruce Macintosh and former LLNL postdoctoral fellow Christian Marois were lead authors on a paper published in the journal *Science* that was a cowinner of this year's American

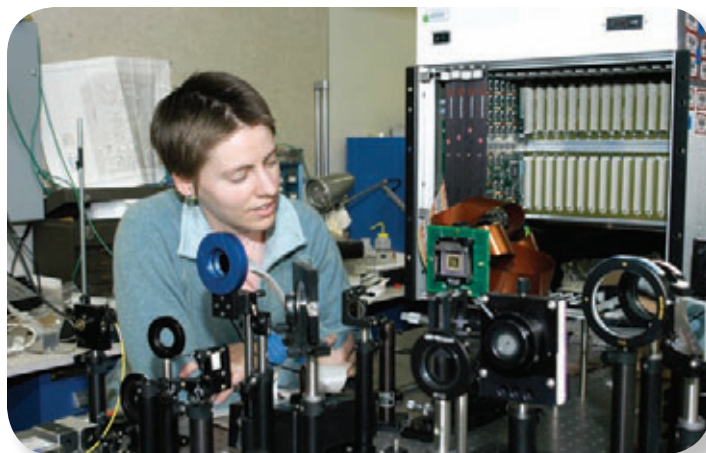
Association for the Advancement of Science (AAAS) Newcomb Cleveland Prize. Their paper discussed the first-ever direct imaging of a multi-planet solar system some 140 light-years away.

Fellows

Nine Laboratory scientists were elected fellows of professional societies in FY2010. David Bradley, Laurence Fried, Arthur Molvik, Christine Orme, and Scott Wilks were named fellows of the American Physical Society. Bill Goldstein was named a fellow of AAAS, Bryan Balazs was elected a fellow of the American Chemical Society, Ray Beach was awarded the rank of fellow of the international optics and photonics society SPIE, and Rick Ryerson was elected a fellow of the U.S. Geochemical Society and the European Association for Geochemistry.

Excellence in Fusion Engineering

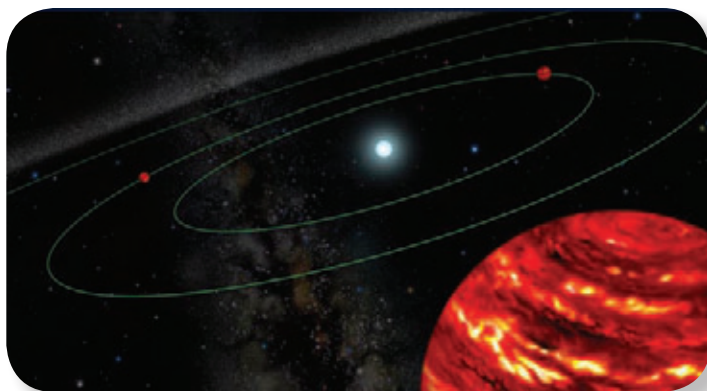
Two Laboratory scientists received Excellence in Fusion Engineering Awards from Fusion Power Associates. Prav Patel was honored for his work in relativistic laser-plasma interaction and his leadership in developing the fast-ignition concept for inertial confinement fusion. Jeff Latkowski was recognized for his work on the Laser Inertial Fusion Engine (LIFE) project,



Omar Hurricane (top), E. O. Lawrence Award; Ed Moses (left), regional Jefferson Award; and Lisa Poyneer (right), Alameda County Women's Hall of Fame were honored in FY2010.



The AAAS Newcomb Cleveland Prize was awarded for a paper by Bruce Macintosh and Christian Marois (lead authors) on the first-ever direct imaging of a distant multi-planet solar system.



the Final Safety Analysis for NIF, and contributions to the national High Average Power Laser program.

Early Career Awards

Computer scientist Greg Bronevetsky and physicist Vlad Soukhanovskii won DOE Early Career Research Program Awards. They are among 69 scientists nationwide who will receive five-year research grants as part of a program designed to bolster the nation's scientific workforce by providing support to exceptional researchers early in their careers.

Outstanding Mentors

Adam Bernstein, Phil Burger, Zafer Demir, Tina Eliassi-Rad, Amy Gaffney, Roger Henderson, Kareem Kazkaz, Gary Laguna, Steve Langer, Christine Orme, Roger Qiu, Robert Rieben, Klint Rose, Dawn Shaughnessy, Jeff Westcott, and Trevor Willey were recognized with DOE Outstanding Mentor Awards.

Outstanding Graduate Student

Tammy Ma, a Lawrence Scholar and postdoctoral researcher at NIF, received the 2010 Mechanical and Aerospace Engineering Award for Outstanding Graduate Student from the University of California at San Diego. Ma's research focuses on electron transport and laser-matter interactions relevant to fast-ignition inertial confinement fusion.

TED Fellowship

Physicist and nanotechnologist Frederick Balagadde was one of 20 individuals selected to comprise the inaugural class of the TED (Technology Entertainment and Design) Senior Fellowship Program.

TED is a nonprofit organization dedicated to innovative "ideas worth spreading" that address global issues. The TED fellows program helps world-changing innovators from around the globe become part of the TED community, and it helps amplify the impact of the fellows' remarkable projects and activities.

Blue Ribbon Commission

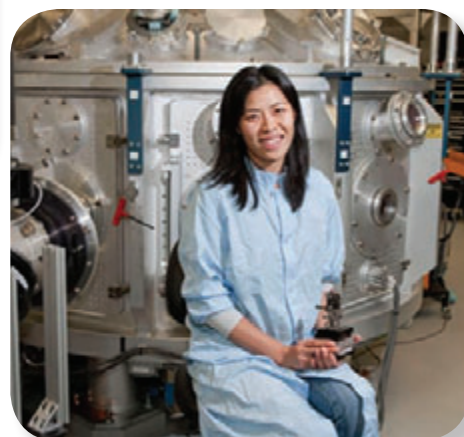
Tom Isaacs, former director of LLNL's Office of Planning and Special Studies and currently on leave at Stanford University, was named lead advisor to the Blue Ribbon Commission on America's Nuclear Future. The commission was formed by the Secretary of Energy to assess current U.S. policies regarding the storage, processing, and disposal of nuclear waste.

R. A. Laudise Prize

Natalia Zaitseva was awarded the R. A. Laudise Prize of the International Organization for Crystal Growth for her work in creating the scientific basis and technology for rapidly growing perfect crystals from solution. The award is presented every three years for significant technological contributions to the field of crystal growth.

Professional Progress Award

Chemical engineer William Smith was honored with the Professional Progress Award, the top award from the Northern California Section of the American Institute of Chemical Engineers. The award is given in recognition of service to the section, professional career achievement, and contributions to the chemical engineering profession.



Tammy Ma won the 2010 Mechanical and Aerospace Engineering Award for Outstanding Graduate Student from the University of California at San Diego.



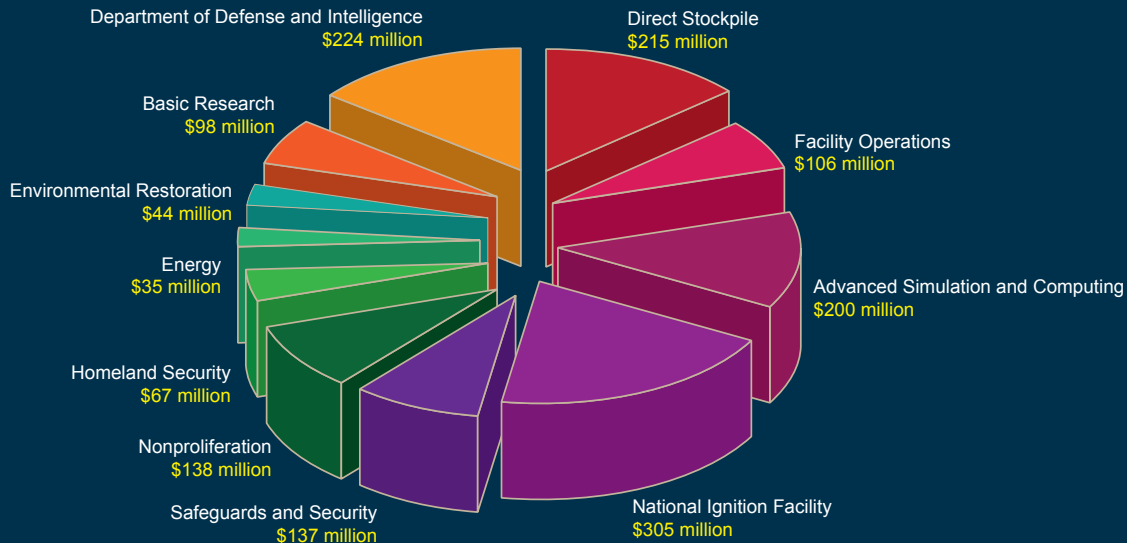
Frederick Balagadde, selected for the inaugural class of the TED Senior Fellowship Program, holds a microfluidic biodetector.



Natalia Zaitseva was awarded the R. A. Laudise Prize for her work on rapid crystal growth.

FACTS & FIGURES

LLNL FY2010 Actual Costs: \$1.570 billion



FY2010 Accomplishments "By the Numbers"

Completed Cycle 15 of the Annual Stockpile Assessment.

Participated in JTA flight tests of the W87 and B83 warheads.

Supported Pantex in the disassembly of all W62 warheads, completed one year ahead of schedule.

Removed more than 75 percent of special nuclear material from the Livermore site (as of October 2006 inventory levels).

Conducted the first integrated ignition experiment, focusing 1 megajoule of energy from NIF's 192 laser beams on a cryogenically layered capsule of hydrogen, deuterium, and tritium.

Installed 44 shield doors, some weighing up to 5 tons, to provide radiation protection in and around the NIF target bay and beam switchyards, and 17 types of new target diagnostics as part of the Ignition Preparation Project.

Completed a 7.5-megawatt power upgrade to the Terascale Simulation Facility in preparation for arrival of Sequoia.

Discovered element 117 as part of an international team of scientists from Russia and the U.S.

Helped discover a new hominid species thought to be at least 2 million years old.

Fabricated eight precision multilayer mirrors for NASA's Solar Dynamics Observatory.

Installed the 261-teraflop/s Sierra supercomputer for unclassified computing.

Determined that the use of various drag-reducing devices on semitrucks could increase fuel efficiency by 12 percent, saving 3.4 billion gallons of diesel fuel each year.

Received one E. O. Lawrence award, one regional Jefferson Award, two Excellence in Fusion Engineering Awards, and 10 NNSA Defense Programs Awards of Excellence.

Saw nine Laboratory scientists elected as fellows of professional societies and one scientist elected to the Alameda County Women's Hall of Fame (the eighth LLNL researcher so honored).

Deployed more than two dozen LLNL technical experts to Houston to assist BP in stemming the Deepwater Horizon oil spill.

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Garnered six R&D 100 Awards and two Federal Laboratory Consortium Awards for Excellence in Technology Transfer.

Received 54 patents, filed 122 patent applications, and submitted 160 records of invention.

Signed 13 new cooperative research and development agreements and 24 new commercial licenses.

Generated \$8.5 million in royalty and licensing income, representing well over \$400 million in sales of products based on LLNL technologies.

Took first place in the Connecticut SWAT Challenge, the nation's second largest SWAT competition.

Assessed 171 buildings for chemical, biological, and other hazards as part of an Industrial Hygiene Baseline project.

Conducted 13 single-facility emergency response drills and one site-wide exercise.

Achieved ISO 14001 certification for our Environmental Management System.

Received a National Safety Council award for 1 million hours of work by Global Security employees without an occupational injury or illness involving days away from work.

Closed 11 buildings as part of our Strategic Space Consolidation project, bringing the total footage to 821,000 gross square feet of space shut down or demolished since FY2008.

Hosted 191 postdoctoral fellows and 302 visiting scientists as well as 380 students and 139 teachers for workshops and research opportunities at the Laboratory.

Sponsored the 14th annual Tri-Valley Science and Engineering Fair for local middle- and high-school students.

Raised more than \$11,000 for the American Cancer Society's Relay for Life.

Donated more than \$3 million through the annual HOME campaign, including \$1 million in matching funds from LLNS.



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